Distributed Energy and Electric Reliability

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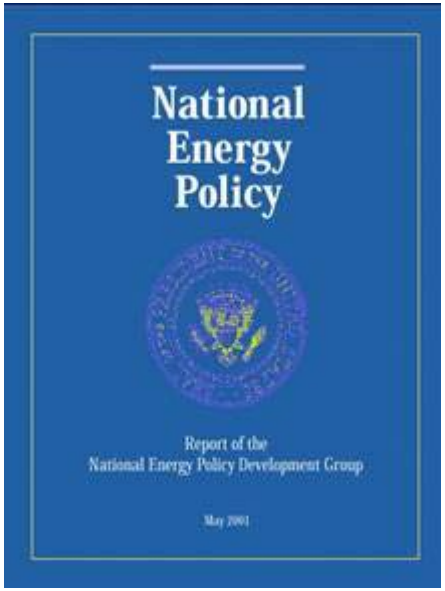
National Energy Policy

Of the 105 total recommendations…

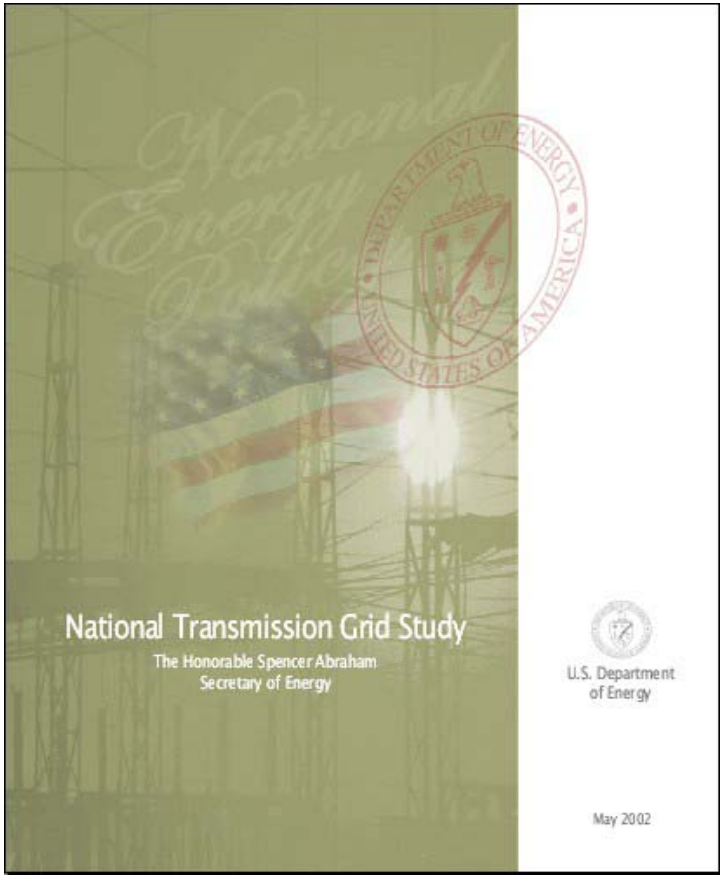
- 21 affect distributed energy
- 17 affect renewable energy
- 13 affect T&D
- 8 affect international activities

www.pi.energy.gov



National Transmission Grid Study

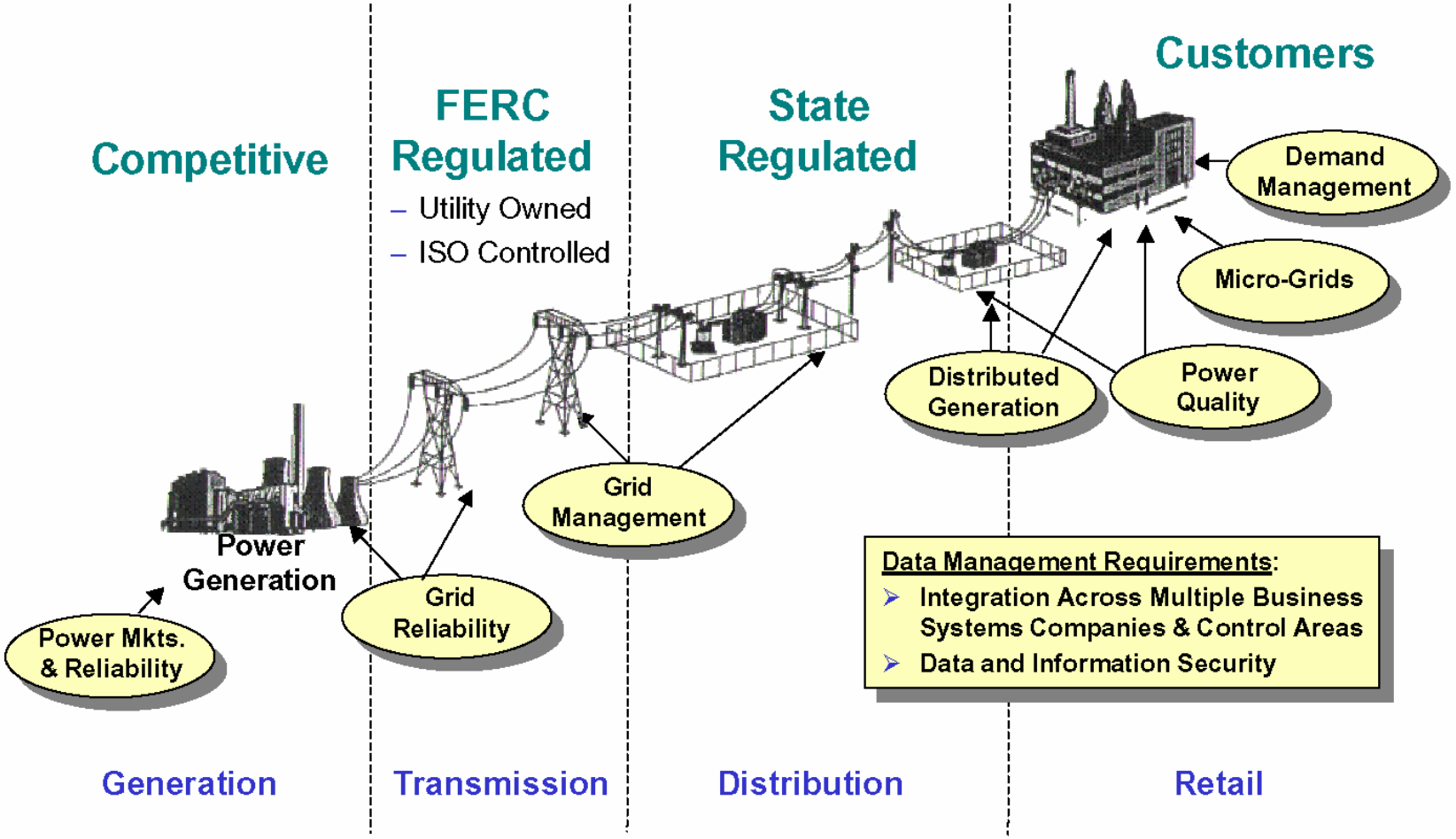
- National Energy Policy Recommendation 7.4a – Examine the benefits of establishing a national grid; identify transmission bottlenecks and measures to remove them
- Final report released May 8
- Website: www.ntgs.doe.gov



National Transmission Grid Study

- Recognizes the importance of DG as an alternative to transmission expansion
- Recommends that regional transmission organizations (RTOs) be responsible for maintaining the reliability of the grid and ensuring that the transmission bottlenecks are addressed
- DOE will continue to work with NGA, regional governors' associations, and NARUC to remove regulatory barriers to voluntary customer load-reduction programs, and targeted energy-efficiency and distributed-generation programs that address transmission bottlenecks and lower costs to consumers

Electric Infrastructure – Needs and Opportunities



Distributed Energy Resources

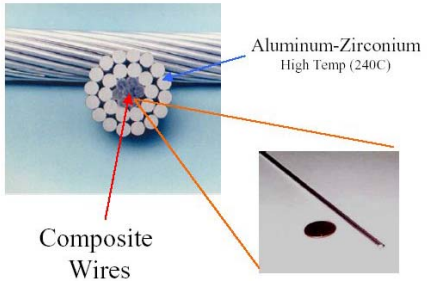
Fuel

Technology Development: Microturbines, recip engines, fuel cells, storage

Technology Packages: CHP systems, hybrids

End-use Integration: Demand management, controls, sensors

Composite Conductor



Utility Integration: Interconnection, power quality, power electronics

Distribution Systems: Load management, power parks, microgrids, storage

Transmission Systems: Reliability, security

Distributed Energy System

Natural Gas Pipeline

Power Grid

Hydrogen Energy

Manufacturing

Solar Building

Housing

CHP

Superconducting "Mini-grid"

Office Building

Fuel Cell

University Campus

Micro-turbine

BCHP

Communications and Controls Center

BCHP

Recip Engine

Neighborhood

Photo-voltaics

Hospital Complex

Data Center

Gas Turbine

Energy Storage

Program Areas

- Distributed Generation Technologies
  - Microturbines and Industrial Gas Turbines
  - Distribution Interconnection
  - Recips
  - Thermally Activated Devices
  - Technology Base
- End-Use Integration
  - Systems Integration
  - CHP
- HTS
- Transmission Reliability
  - Electricity Restructuring
  - Storage

Distributed Gas Fired Technologies

Microturbines

2000
- $900-$1,200/kW
- 17-30% Efficiency
- Double digit ppm NO_x

2007
- Cost competitive with the market
- 40% Efficiency
- Single digit ppm NO_x

Fuel Cells

1997
- $4,000-$10,000/kW
- 80 degrees C
- Natural gas and propane fuels

2010
- $600/kW
- 120-140 degrees C
- Multiple fuels

Gas Turbines

1992
- 29% efficiency
- Double digit NO_x
- $600/kW

2001
- 38% Efficiency
- Single digit NO_x
- $400/kW

2010
- Cost competitive with the market
- <5 ppm NO_x

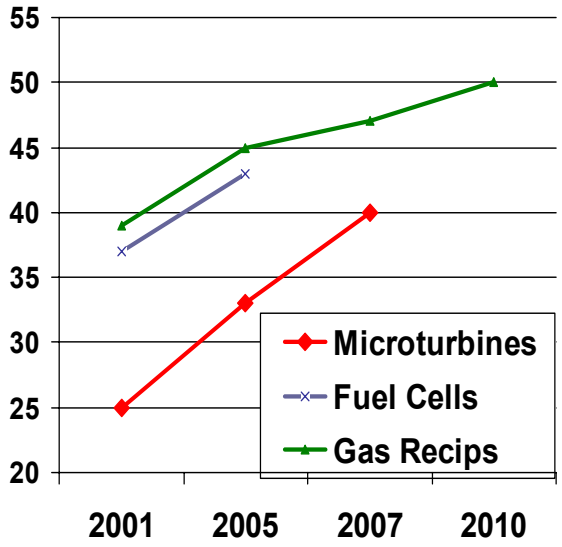
Reciprocating Engines

2000
- $300-$400/kW
- 25-40% Efficiency
- 2-3 grams/kWh NO_x

2007
- Cost competitive with the market
- 50% Efficiency
- < 0.15 grams/kWh NO_x

Technology Comparison

Simple Cycle Efficiency

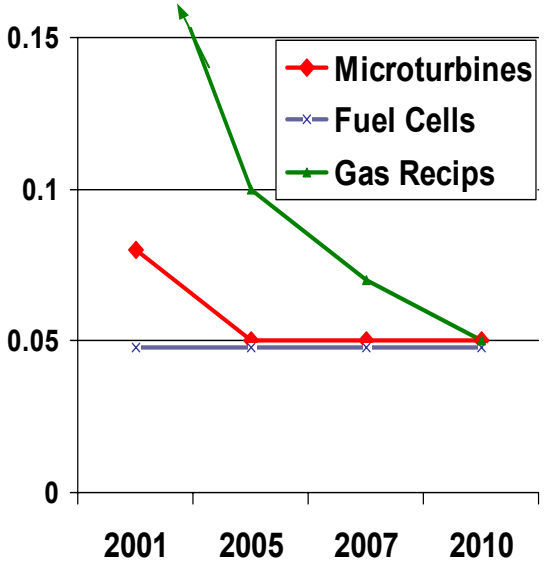


Main Challenge

Microturbine Efficiency Gains

Combustor Temp Limits
Gas Pressure Limits
Turbine Cycle Inefficiencies
Short Track Record

NOx Emissions (g/bhp-hr)

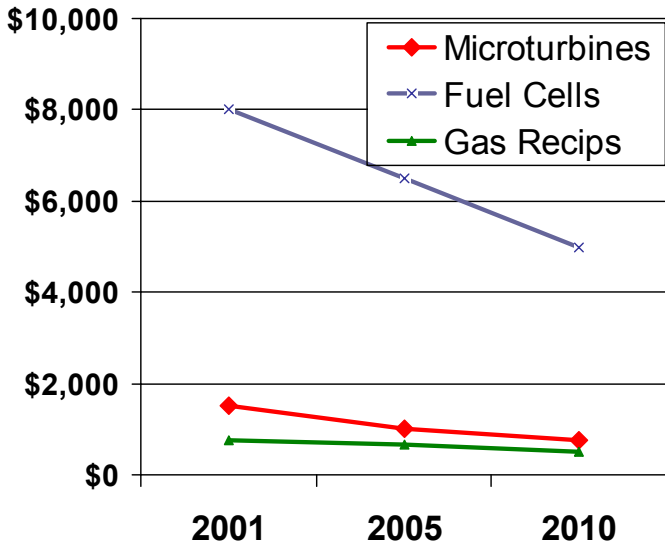


Main Challenge

Engine Emissions Reduction

Combustion Time Limits
Exhaust Temp Limits
Aftertreatment Integration
Multiple Applications

First Cost / kWe



Main Challenge

Fuel Cell Cost Reduction

Gas Reformer Costs
Stack Durability
Power Electronics Costs
Low Volume Structure

Superconductivity

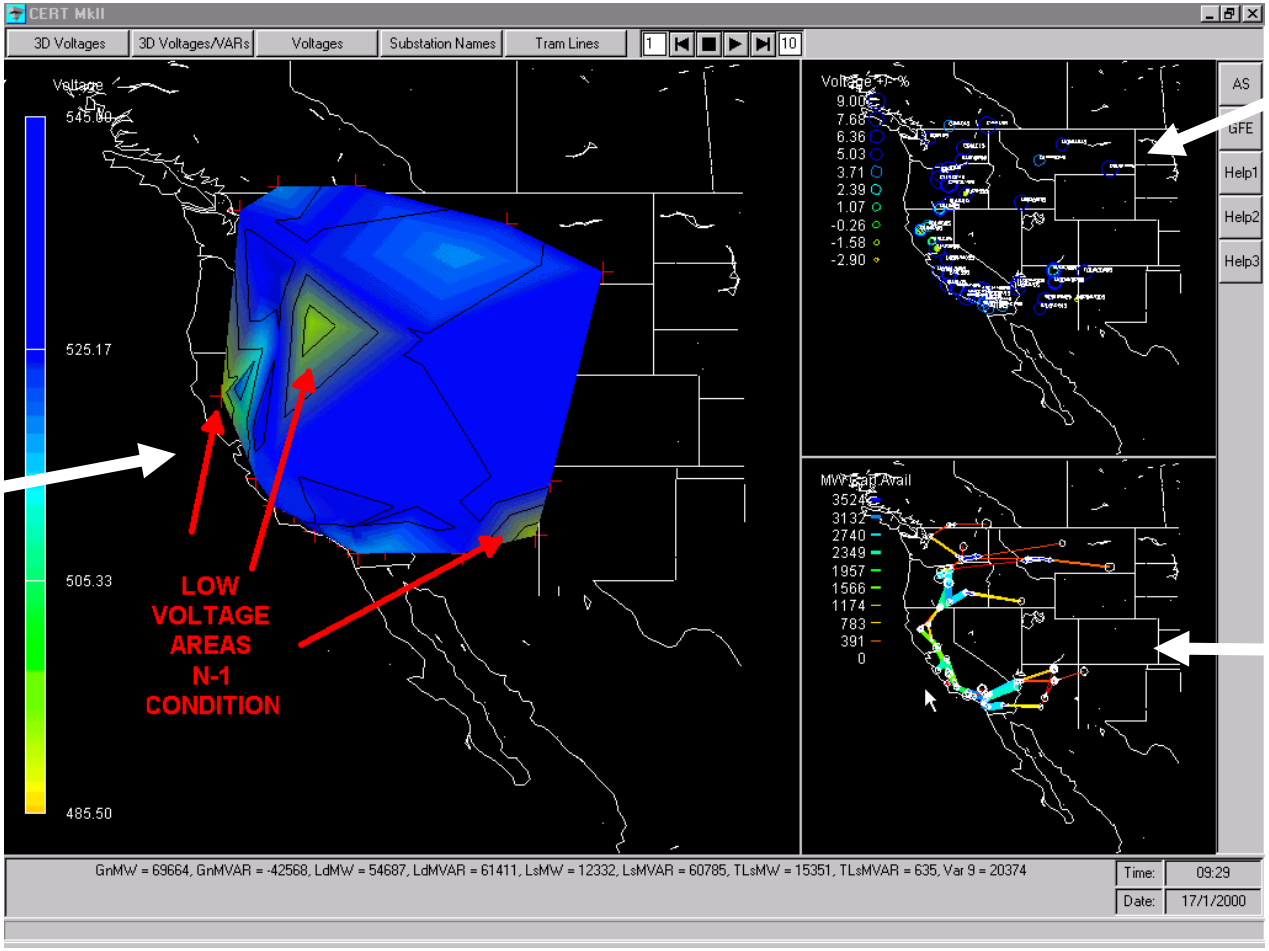
Goals

- **Wires:** HTS wires will carry 100 times the current without the resistance losses of comparable-diameter copper wire.
- **Equipment:** HTS equipment is half the size of conventional alternatives with the same power rating, and has only half the energy losses.

Transmission Tools

Visual Perspective Selection

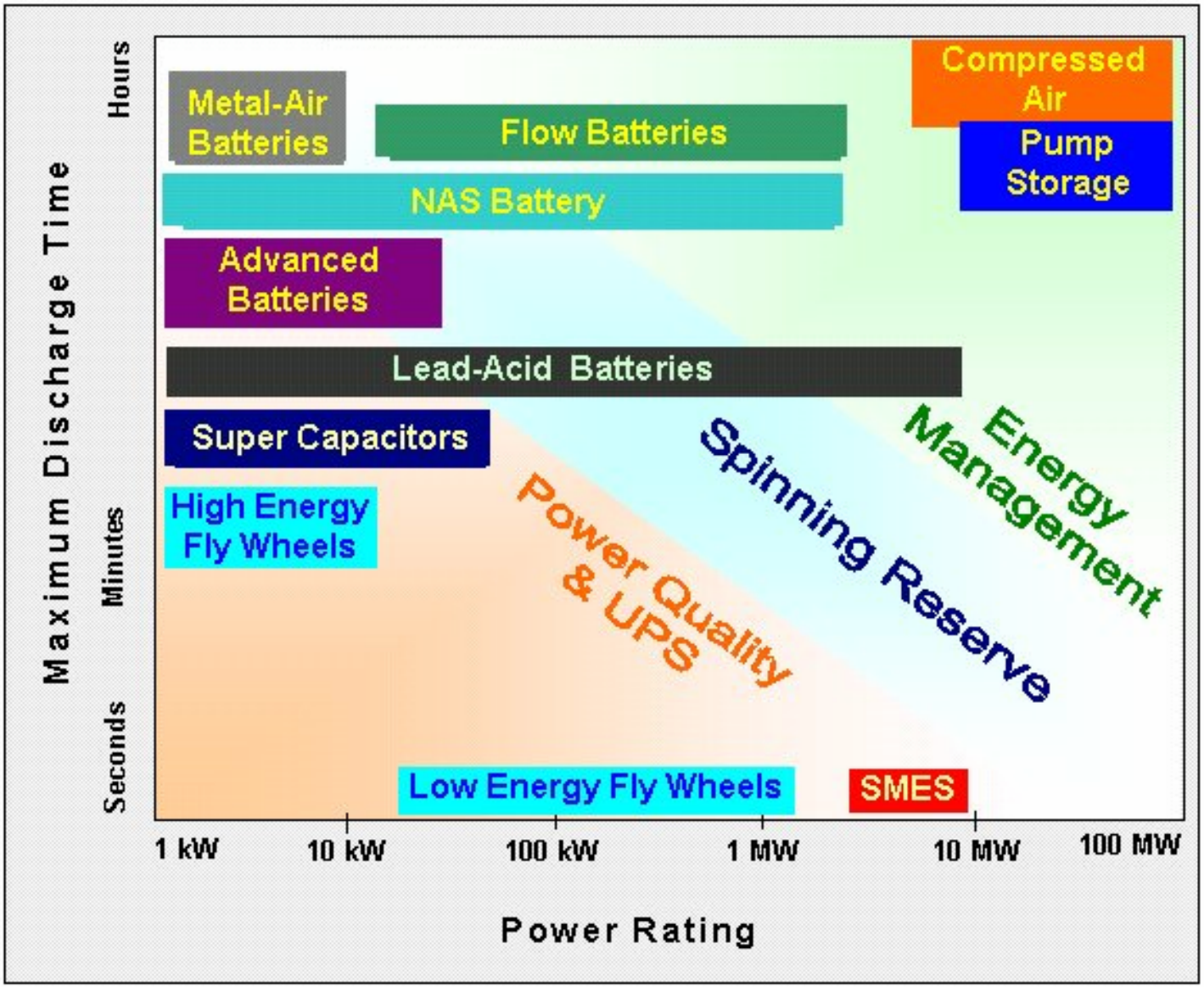
Main Panel Isovoltages



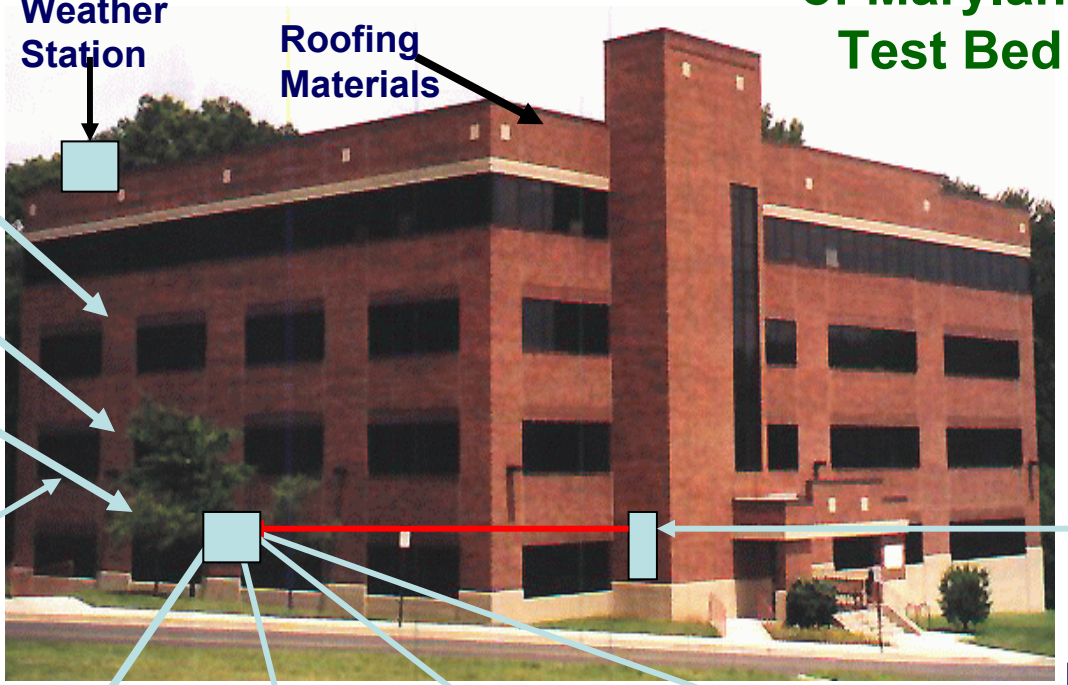
Sub Panel1 Alarms

Sub Panel2 Encoded Flows

Energy Storage



Integration of Distributed and CHP Systems



University of Maryland Test Bed

Windows Thermal Pane

Weather Station

Roofing Materials

Advanced Building Materials, Insulation

Foundation

Ventilation
-Ducts
-Piping
-Fans
-Blowers

Low Voltage Grid

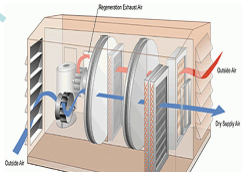
Controls DG

Instrumentation

Humidity Control

Power

Heating/Cooling



Indoor Air Quality

Storage

Reject

System Integration R&D

- Universal plug-and-play interconnection system
  - Inverter-based plug-and-play across multiple technologies
  - Fully integrated utility-grade switchgear, metering, and system-level command and control for synchronous machines <500kW
- Enterprise energy management technology
  - Aggregation
  - Microgrids
- Automated adaptive intelligent interconnection and control
- Modeling
- Laboratory and Field Testing

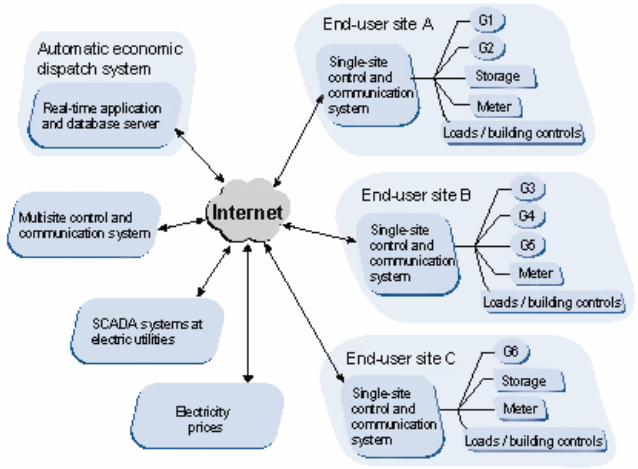
NREL DER Test Facility

Test Equipment
- Distributed Generation
- Distributed Storage
- Protective Equipment
- Switches
- Electronics
- Communications and Controls

Measurements
- Power Quality
- Stability
- Response to Disturbances
- Performance/ Functionality

Specific Tests
- Validation of P1547 Requirements
- Development of P1589 Procedures
- Over/Under Voltage
- Over/Under Frequency
- Islanding
- Surge Withstand

Pathway for Integrated DER Systems and Controls



Centralized hierarchical control at power plants

DER systems integrated and controlled at a single sites

"Virtual utilities" with aggregated control of integrated DER systems across multiple sites

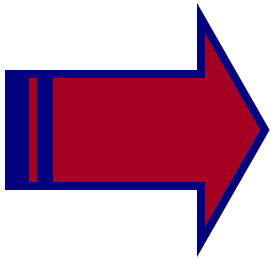
2000 **2005** **2010**

End State Enabled by the C&C Program

Effective Integration of Distributed Energy Systems into Customer Operations and Utility Systems

Current

- Radial grid – one-way flow
- Electromechanical devices
- Utility control
- Rigid architecture



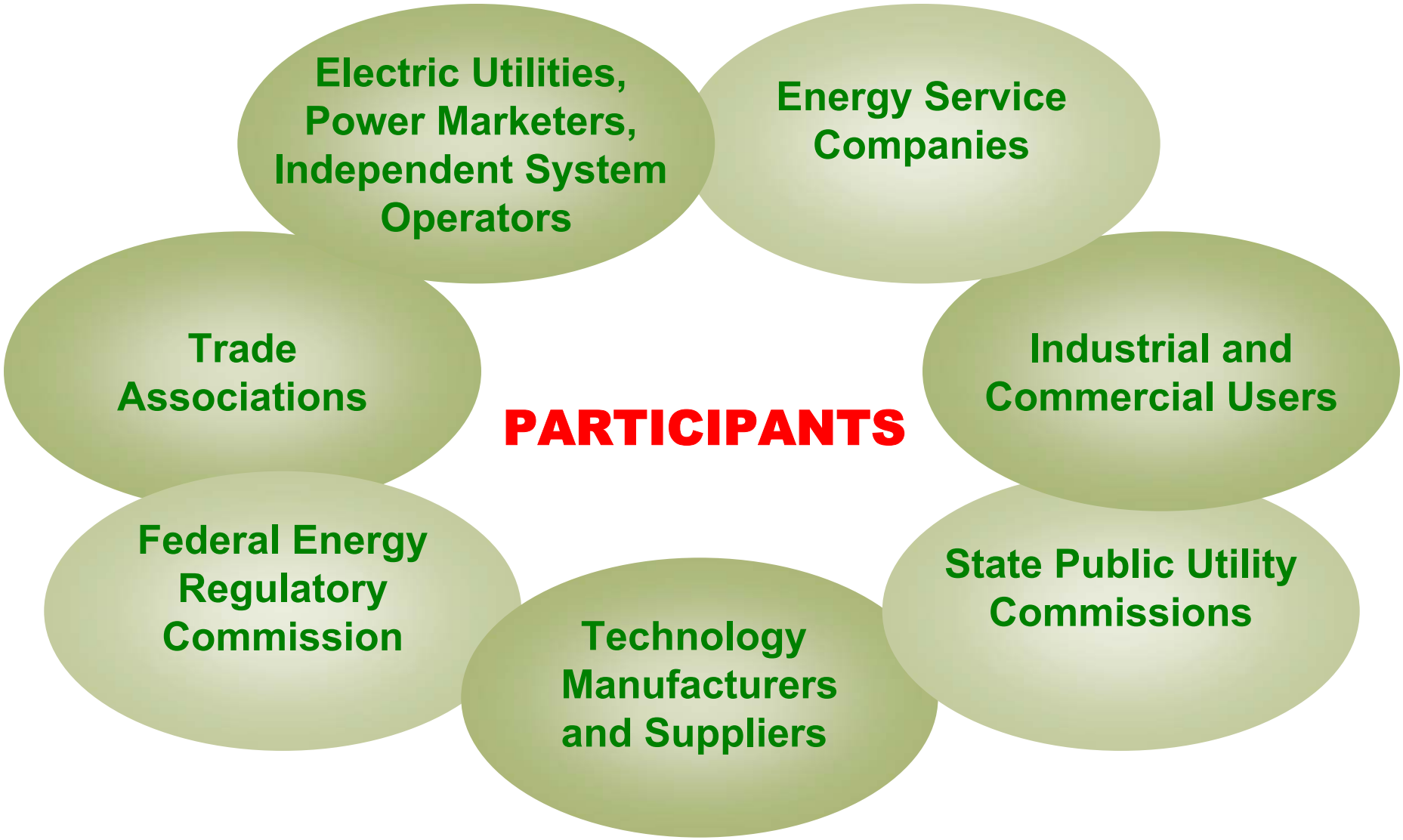
End State

- "Plug&play" protocols
- Digital devices
- Customer control
- Flexible architecture

Integration and Controls Demonstrations

- Solicitation for integrated demonstration of communication and control solutions to be released in November
- Demonstrate sensing, communication, information and control technologies to:
  - achieve a seamless integration of multi-vendor DER units at aggregation levels that meet individual user requirements for facility operations
  - serve as resource options for electric and natural gas utilities
- The fully demonstrated DER aggregation system will lead to real-time, interactive customer-managed service networks to achieve greater customer value.

Industry-Driven Roadmap Process



Strategic Partnerships

- www.eren.doe.gov/der
- Technical publications
- Workshops and conferences
- Technology planning
- Cost-shared RD&D